

AN ANALYSIS OF THE EFFECTS OF  
RESPONSE REPETITION ON SIGHT-WORD READING

By

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AN ANALYSIS OF THE EFFECTS OF  
RESPONSE REPETITION ON SIGHT-WORD READING

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Acquisition of a skill involves both increases in correct performance and decreases in incorrect performance. Thus, consequences are often arranged for correct responses and errors during skills training to facilitate acquisition. Whereas a great deal is known about the effects of positive reinforcement (i.e., rewards) on performance, much less is known about the influence of error-correction procedures. The present series of experiments was conducted to evaluate the effects of response-repetition error correction on the sight-word reading performance of 7 adults with developmental disabilities.

In Experiment 1, the effects of single-response (SR) repetition and multiple-response (MR) repetition procedures were compared. Initial results showed similar rates of acquisition during the two conditions. Over time, however, all participants acquired more sight words when the MR procedure was used to correct errors.

In Experiment 2, the effects of consistent and intermittent application of MR error correction were compared. Results showed that better sight-word performance was observed in all cases when every error was corrected rather than when a varying proportion of errors was corrected.

In Experiment 3, an attempt was made to identify the learning process(es) underlying sight-word acquisition during MR error correction. Sight-word performance was compared during conditions in which errors resulted in (a) Relevant MR (i.e., repetitions of the training word), or (b) Irrelevant MR (i.e., repetitions of a different word). Results showed that 3 out of 5 participants acquired more sight words during the relevant condition, whereas the remaining 2 participants acquired a similar number of sight words during both conditions. These results suggest that MR improves sight-word skills through negative reinforcement (avoidance of error correction), although in some cases, MR may also serve to enhance stimulus control over correct performance.

## INTRODUCTION

Behavioral techniques frequently are used to enhance learning in instructional settings. When acquisition of a skill is the desired outcome, two changes must occur: (a) Correct responses must increase, and (b) incorrect responses must decrease. To facilitate these changes in behavior, positive reinforcement (e.g., praise, edibles) typically is delivered following correct responses, and an error-correction procedure is implemented following incorrect responses. The combined use of consequences for both correct and incorrect performance has resulted in the acquisition of numerous behaviors, including manual signing (Carr & Kologinsky, 1982; Remington & Clarke, 1983), social interaction (Gaylord-Ross, Haring, Breen, & Pitts-Conway, 1984; Lalli, Pinter-Lalli, Mace, & Murphy, 1991), motor skills (Correa, Poulson, & Salzberg, 1984; Kirby & Holborn, 1986), self-care skills (Horner & Keilitz, 1975; Nutter & Reid, 1978), spelling (Birnie-Selwyn & Guerin, 1997; Neef, Iwata, & Page, 1980), and reading comprehension (Pany, McCoy, & Peters, 1981; Rosenbaum & Breiling, 1976).

Despite the fact that error-correction procedures are widely used as a component of training, little is known about the relative contribution of these procedures to the process of acquisition. Increases in correct performance observed during acquisition overwhelmingly are attributed to the effects of positive reinforcement (Cooper, Heron, & Heward, 1987; Miltenberger, 2001). Nevertheless, because error-correction procedures are so pervasive in training contexts, it may be important to examine more closely the extent to which error correction influences skill acquisition.

Wide variation exists in the procedures used to correct errors. One of the most frequently reported error-correction procedures involves the delivery of single or multiple prompts to emit a correct response after an incorrect response occurs. That is, when an error is made, the correct response is supplied by the therapist, and the participant is given an additional opportunity to respond independently. Researchers have shown improvements in correct performance with the use of vocal prompts to continue the task (Cowley, Green, & Braunling-McMorrow, 1992; Koegel & Egel, 1979), imitative models of correct performance (Carr & Kologinsky, 1983; Wheeler & Sulzer, 1970), and manual prompts to complete the correct response (Hinerman, Jenson, Walker, & Peterson, 1982; Remington & Clarke, 1983).

#### Parametric Evaluations of Amount of Error Correction

Although the effectiveness of both single and multiple prompts has been demonstrated, few researchers have investigated the amount of prompting necessary to produce increases in correct performance. Close, Irvin, Prehm, and Taylor (1978) compared 6 different prompting techniques to determine their effects on the vocational performance of 70 adults with severe mental retardation. Participants were randomly divided into groups, and each group received one variation of a verbal and/or physical prompting procedure (e.g., specific and general verbal prompts versus specific and general physical assistance). One of the most interesting manipulations involved a between-groups comparison of the effects of amount of prompting on acquisition. One group received a single physical prompt contingent on each error; another group received five repetitions of physical prompting following each error. Results indicated that the task was acquired more quickly by the group that received multiple repetitions of

physical prompting, and these findings suggest that the speed of acquisition may be enhanced when more extended exposure to prompting is provided.

Different amounts of physical prompting also were compared by Carey and Bucher (1983). The task involved placement of various objects into their appropriate containers, and observers measured correct responses, off-task behavior (no functional manipulation of task materials within 3 s), and negative side effects (aggression, disruption). During baseline, correct object placement resulted in brief feedback (e.g., "that's right"), and off-task behavior produced no consequences. During training, the consequence for off-task behavior involved physical guidance of the correct response for either 30 s or 3 min. Results showed that short and long durations of physical guidance were equally effective in producing rapid acquisition. Although no difference in acquisition rate was observed between the two conditions, two minor drawbacks of the long-duration error-correction procedure were noted: (a) More negative side effects were observed, and (b) more treatment time was required to reach the acquisition criterion (80% correct object placement across 2 consecutive sessions).

In the context of sight-word training, emphasis has been placed on prompting strategies that involve varying amounts of exposure to the misread word following an error. For example, during single-response (SR) repetition prompting (also known as whole-word correction or word supply), the therapist recites the entire word after an error is made and requires the participant to repeat it one time. By contrast, during multiple-response (MR) repetition error correction, the therapist prompts the participant to recite the correct word several times before a new word is presented. Both SR and MR error correction have been demonstrated to be successful in improving sight-word performance

(Barbetta, Heward, & Bradley, 1993; Espin & Deno, 1989; Rose, McEntire, & Dowdy, 1982; Singh & Singh, 1986). To date, however, no study has directly compared the relative efficacy of these two prompting procedures, so it is unknown whether additional prompting during error correction would facilitate sight-word acquisition.

#### Processes Underlying Error-Correction Procedures

When prompting is used to correct errors, improvements in performance have been attributed to one of two behavioral processes (Singh & Singh, 1988). First, the delivery of prompts may provide additional "practice" with the stimuli associated with correct and incorrect responses, thus resulting in improved stimulus control over future correct responses. Alternatively, it is possible that prompting is a punishing rather than an "educational" event, and that increases in correct responses are the result of negative reinforcement (i.e., avoidance of error correction). In most error-correction studies involving prompting, it is impossible to isolate which of the two processes influences behavior because they are confounded. However, two studies have attempted to separate the effects of practice from those of avoidance by including a condition in which topographically dissimilar stimuli were presented during error correction.

Axelrod, Kramer, Appleton, Rockett, and Hamlet (1984) compared topographically similar ("relevant") and dissimilar ("irrelevant") error-correction procedures on spelling performance. During the relevant condition, children were required to correctly spell all error words from the weekly pretest, write their parts of speech and phonetic spelling, and use them in 5 sentences. The irrelevant condition was identical to the relevant condition except that the words were not taken from the weekly pretest (i.e., the words were not targeted during the weekly spelling lesson). Results showed that both procedures produced increases in spelling accuracy on weekly tests,

suggesting that topographical similarity may not be necessary to produce increases in correct responses. Further, because practice with weekly spelling words was not provided in the irrelevant condition, the increases in spelling accuracy observed during this condition were likely due to negative reinforcement.

Relevant and irrelevant error-correction procedures also were compared by Rodgers and Iwata (1991) in an attempt to separate the effects of stimulus control from those of negative reinforcement. Match-to-sample (MTS) training was conducted with 7 adults with developmental disabilities, and training stimuli included Greek letters, geometric shapes, and arbitrary graphic symbols. Across all training conditions, correct responses resulted in praise (e.g., "good, that's right") and either an edible or a penny. During the relevant ("practice") condition, errors were followed by re-presentation of the MTS trial until a correct response occurred. By contrast, in the irrelevant ("avoidance") condition, incorrect responses resulted in the presentation of practice trials with different stimuli (a color-matching task). Results showed that 3 participants performed better when irrelevant stimuli were presented during error correction, whereas the other 4 participants performed better when relevant stimuli were presented. Because negative reinforcement was the common mechanism operating during both correction procedures, the authors concluded that improvements in performance were due in part to avoidance. The superior MTS performance observed for some participants during the relevant condition further suggested that enhanced stimulus control contributed to acquisition.

The purpose of this series of experiments was to systematically evaluate the effects of a commonly used error-correction procedure, response repetition, on the acquisition of sight-word reading skills. In Experiments 1 and 2, varying amounts of

response repetition were compared to determine the extent to which error-correction amount influences sight-word reading performance. Experiment 3 was conducted in an attempt to examine the behavioral process(es) involved in error correction during sight-word acquisition.

## GENERAL METHOD

### Participants and Setting

Seven adults with developmental disabilities participated in one or more of three experiments (participant information is listed in Table 1). The participants were employed at a sheltered workshop established by the Association for Retarded Citizens (ARC). All but 2 participants (Ernie and Seth) were involved in a continuing education program at the workshop, which typically consisted of instruction in daily living skills (e.g., money management, safety skills), although some academic instruction was provided. Individuals were selected for participation in one or more of the experiments based on caregiver or teacher report of a need for improvement in sight-word reading skills. Throughout the study, none of the participants received explicit sight-word instruction other than during experimental sessions.

Sessions were conducted 3 to 5 days per week in quiet areas adjacent to the participants' worksites. The length of sessions varied both within and across the three experiments, although an individual session never lasted more than 13 min (range, 1.9 to 12.3 min). All training and testing sessions were conducted individually, with the therapist and participant seated across from one another at a table and observers seated in close enough proximity to hear the participant's responses.

Table 1. Participant characteristics.

| Name   | Age | Diagnosis                                          | Reading Level |
|--------|-----|----------------------------------------------------|---------------|
| Ernie  | 23  | Moderate mental retardation, Prader-Willi Syndrome | N/A           |
| Seth   | 23  | Moderate mental retardation, Down Syndrome         | Grade 3       |
| Robin  | 37  | Moderate mental retardation                        | N/A           |
| Ariel  | 23  | Mild mental retardation, Prader-Willi Syndrome     | Grade 2       |
| Hayley | 33  | Mild mental retardation, Prader-Willi Syndrome     | Grade 3       |
| Becky  | 20  | Moderate mental retardation, Prader-Willi Syndrome | Grade 3       |
| Tess   | 27  | Mild mental retardation, Prader-Willi Syndrome     | Grade 3       |

#### Sight-Word Selection, Pretesting, and Mastery Criterion

A pool of words was assembled to serve as potential training and testing stimuli. Words were grouped in lists and were designated either by a specific grade level (1-5), or by a "5+" if the words were above a fifth-grade reading level. A pretest similar to that conducted by Barbetta, Heward, and Bradley (1993) then was conducted with each person to identify novel (i.e., unknown) words. Word lists selected for pretesting were at least one grade level above a participant's current reading level. During the pretest, participants were instructed to try their best to read each word without making a mistake. Words were presented one at a time, and participants were given 5 s to respond. No consequences were delivered for either correct or incorrect responses, but noncontingent praise (e.g., "nice reading") was delivered intermittently to maintain attention to the task. Words read correctly during the first pretest were omitted from the word list, and the

remaining words were pretested a second time. Words read incorrectly during both pretests were considered unknown and were used as training stimuli.

For those participants who exhibited minor speech difficulties (Ariel and Seth), an additional pretest was conducted to identify acceptable alternative pronunciations of words. Unknown words were read aloud by the therapist, and the participant was prompted to repeat each word. If the participant was unable to emit a close approximation to an unknown word, then the word was omitted from the list of training words. However, if the participant's pronunciation of a word sufficiently resembled the correct pronunciation (e.g., saying "ceweal" after hearing "cereal"), then the word was kept in the pool of training words and the alternative pronunciation was regarded as correct.

Each of the three experiments involved a comparison between two error-correction procedures. A set of eight unknown words was assigned to each of the two training conditions, and words within a set were presented three times per session (yielding 24 word presentations). In an attempt to equate word difficulty across the two conditions, an equal number of one- or multi-syllable words were included within each word set. Words were printed by hand on 3" x 5" index cards, and different colored cards were used to designate the two word sets. To ensure some familiarity with the correct pronunciation of words, whenever a new word was introduced into a word set, the word card was shown to the participant and the word was read out loud prior to daily training sessions.

A mastery criterion was developed so that correctly read words were consistently replaced by new, unknown words. A word within a set was considered "mastered" if it was read correctly on every presentation within a training session (i.e., three consecutive

times during one session). Once a word was mastered, it was removed from the array and was replaced with a new, unknown word.

### Retention Tests

Two types of tests were conducted to evaluate whether words meeting the mastery criterion during training would be retained over both brief and more extended periods of time. The first test, a short-term retention test, included all words that were mastered during the previous day's training sessions. On most days, a short-term retention test was conducted approximately 24 hours after a word (or words) was mastered during training. However, because of weekend hiatuses and unscheduled absences from the worksite, the time between word mastery and short-term testing was extended to a maximum of 72 hours. If more than 72 hours elapsed between word mastery and testing, then a short-term retention test was not conducted. The second test, a long-term retention test, was administered once per week and included all words that were mastered during the previous week's training sessions.

Prior to each short- or long-term retention test, the participant was instructed in the following manner: "Here are some words that you've learned in our reading sessions. You won't get any (reinforcer), but please try your best to read each word without making a mistake." The therapist then shuffled the mastered word cards and presented each one for 5 s. No consequences were provided for either correct or incorrect responses during testing.

### Reinforcer Identification

A multiple-stimulus without replacement (MSWO) preference assessment (DeLeon & Iwata, 1996) was conducted with all participants to identify preferred stimuli for use as consequences for correct performance during training. For those participants

with dietary restrictions (i.e., participants diagnosed with Prader-Willi Syndrome), only leisure activities or calorie-free drinks were used in the array. Edible items were assessed for the remaining participants. To ensure familiarity with the stimuli being assessed, participants were prompted to sample each food or drink item or were given brief access to each leisure activity prior to the assessment. The preference assessment began with all stimuli being placed in a straight line or in an arc-shape on the table within reach of the participant. The participant was instructed to select her/his "favorite" item. Once a selection was made (i.e., once the participant touched one of the items), s/he was permitted to consume the edible or drink or to interact with the activity for approximately 30 s. The item that had been selected was not replaced into the array on subsequent trials, and item placement within the array was randomly rotated across trials. These procedures continued until all items were selected. The number of items assessed ranged from 7 to 16 across participants, and the preference assessment was conducted either one time (Ernie, Ariel, Hayley, Becky, and Tess) or was repeated three times (Seth and Robin).

Based on the results of the preference assessment, one or more stimuli were selected for use during training. In those cases in which leisure item preference was assessed (Ernie, Ariel, Hayley, Becky, and Tess), a token economy was developed to dispense reinforcers. Stimuli identified as moderately-to-highly preferred during the assessment were compiled to create a reinforcer menu. Each correct response made during baseline or training resulted in the delivery of one ticket. Following each session, tickets were exchanged for access to one or more of the preferred activities listed on the menu. By contrast, in those cases in which preference for edibles was assessed (Seth and

Robin), the most highly preferred edible identified during the assessment was used as a consequence for correct responses.

### Response Measurement and Reliability

Psychology graduate and undergraduate students used laptop computers to record the frequency of correct and incorrect responses during training sessions. A response was scored as correct if the participant accurately pronounced a word within 5 s of its presentation. A response was scored as incorrect (i.e., an error) if the participant's vocal response did not match the word displayed on the index card (including mispronunciations, omissions, or substitutions). An incorrect response also was scored if the participant said "I don't know" or failed to respond within 5 s of the presentation of a word card. Across all three experiments, the primary dependent variable was the cumulative number of words meeting the mastery criterion (i.e., correct pronunciation of a word three consecutive times within a session), and observers used paper and pencil to keep a running tally of the number of words mastered during each session. Data were also collected on several therapist behaviors, including the delivery of reinforcers, the onset of error correction, and the percentage of intervals during which error correction occurred.

During the retention tests, data were collected using paper and pencil. Observers recorded whether a word was correct or incorrect by placing a check-mark in the appropriate column on the data sheet.

Interobserver agreement (IOA) was assessed by having a second observer simultaneously but independently collect data with the primary observer during 35% of all training sessions (38% of sessions in Experiment 1, 30% of sessions in Experiment 2, and 37% of sessions in Experiment 3). IOA measures were taken for 43% of all short-

term retention tests (51% in Experiment 1, 34% in Experiment 2, and 44% in Experiment 3), and for 47% of all long-term retention tests (52% in Experiment 1, 37% in Experiment 2, and 52% in Experiment 3).

Percentage agreement scores were calculated in three ways. In the case of frequency measures (correct/incorrect responses during training, reinforcer deliveries, and error correction presentations), agreement was calculated by first dividing each session into 10-s intervals. The smaller number of responses in each interval was divided by the larger number of responses, and these fractions were averaged across intervals and multiplied by 100%. Mean agreement for correct responses was 95% (range, 92% to 97%) during Experiment 1, 97% (range, 92% to 99%) during Experiment 2, and 96% (range, 96% to 98%) during Experiment 3. Mean agreement for incorrect responses was 94% (range, 91% to 95%) during Experiment 1, 93% (range 90% to 96%) during Experiment 2, and 94% (range, 89% to 97%) during Experiment 3. Mean agreement for reinforcer delivery was 94% (range, 92% to 97%) during Experiment 1, 95% (range, 91% to 97%) during Experiment 2, and 95% (range, 93% to 97%) during Experiment 3. Mean agreement for error-correction presentation was 94% (range, 92% to 97%) during Experiment 1, 96% (range, 95% to 98%) during Experiment 2, and 93% (range, 89% to 96%) during Experiment 3.

For the partial-interval measure (percentage of intervals during which error correction occurred), interval agreement was calculated by dividing the total number of agreements by the total number of intervals in a session. Mean agreement for error-correction occurrence was 91% (range, 87% to 94%) during Experiment 1, 95% (range, 93% to 97%) during Experiment 2, and 91% (range, 88% to 95%) during Experiment 3.

Finally, for the paper/pencil measures (words mastered and correct responses during testing), a total agreement score was calculated by dividing the smaller number of correct responses by the larger number of correct responses and multiplying by 100%. Mean agreement for words mastered was 99% (range, 98% to 100%) during Experiment 1, 99% (range, 98% to 100%) during Experiment 2, and 98% (range, 97% to 100%) during Experiment 3. Mean agreement for correct responses during short-term retention tests was 94% (range, 86% to 100%) in Experiment 1, 97% (range, 95% to 99%) in Experiment 2, and 98% (range, 94% to 100%) in Experiment 3. Mean agreement for correct responses during long-term retention tests was 92% (range, 78% to 100%) in Experiment 1, 95% (range, 86% to 100%) in Experiment 2, and 95% (range, 89% to 100%) in Experiment 3.

## EXPERIMENT 1: NUMBER OF REPETITIONS DURING ERROR CORRECTION

Researchers have shown that acquisition may be enhanced by increasing the amount of error-correction presented after an incorrect response occurs (Close et al., 1978; Foxx & Jones, 1978). The purpose of this experiment was to examine the effects of amount of error-correction (i.e., number of response repetitions following an error) on sight-word acquisition. Ernie, Seth, Robin, Ariel, and Hayley participated in Experiment 1.

### Procedures

Baseline lengths were staggered to conform to a multiple baseline across subjects design. Following baseline, two error-correction conditions with differing amounts of response repetition were alternated in a multielement design.

#### Baseline (No Error Correction)

A set of eight words was presented in random sequence three times per session, yielding a total of 24 trials. Word cards were presented one at a time, and participants were prompted to read each word. Correct responses resulted in the delivery of a preferred edible (Seth and Robin) or a ticket that was exchangeable for post-session access to preferred items or activities (Ernie, Ariel, Hayley). Incorrect responses were ignored (i.e., they resulted in presentation of the next word card). Following each session, five small pieces of food (Seth and Robin) or five tickets (Ernie, Ariel, Hayley) were delivered noncontingently to participants for "trying hard."

### Single-Response (SR) Repetition

The presentation of word cards, consequences for correct responses, and post-session delivery of reinforcers were identical to the baseline condition. However, rather than ignoring incorrect responses as was done in baseline, the therapist initiated a single-response (SR) repetition procedure following each error made by the participant. The SR procedure consisted of the therapist modeling the correct pronunciation of a word and requiring the participant to repeat the word one time. That is, when a participant made an incorrect response, the therapist said, "No, the word is \_\_\_\_\_. Say \_\_\_\_\_." Following the participant's vocal imitation of the correct word, the next word card was presented.

### Multiple-Response (MR) Repetition

Similar procedures as those used during the single-response repetition condition were conducted, with the following exception: Errors during this condition were corrected using a multiple-response (MR) repetition procedure. The MR procedure consisted of the therapist modeling the correct pronunciation of a word and prompting the participant to repeat the word five times. That is, contingent on each error, the therapist said, "No, the word is \_\_\_\_\_. Say \_\_\_\_\_." After the participant imitated the therapist's model five times, the next word card was presented.

### Results and Discussion

Figure 1 shows the cumulative number of words meeting the mastery criterion for each participant in each condition. When no error-correction procedure was in effect during baseline, very few words were mastered by the participants (range, 0 to 10). The rate of word mastery increased noticeably when the SR and MR procedures were implemented, with the best performance being observed during the MR condition in all cases.

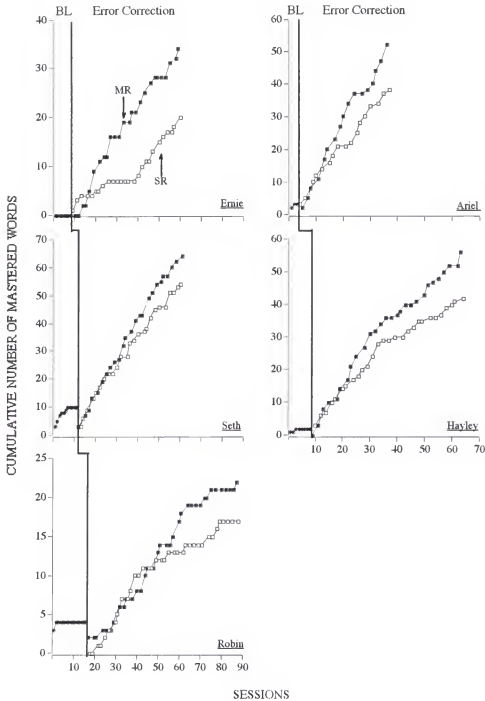


Figure 1. The cumulative number of words meeting the mastery criterion for each participant during baseline (BL), single-response (SR) repetition, and multiple-response (MR) repetition conditions.

Ernie showed the largest differences in performance between the two error-correction conditions, mastering 70% more words in the MR condition than in the SR condition. In the other cases, differences were noticeable but not as large. Across the remaining participants, an average of 30% more words were mastered during the MR condition as opposed to the SR condition. It is interesting to note that Seth's, Ariel's, and Hayley's acquisition rates under the two error-correction conditions were very similar at the start of the intervention phase. It was only after several exposures to the two procedures that the MR condition produced a better rate of sight-word acquisition.

Figure 2 displays the mean number of words read correctly per session by each participant during SR and MR error correction (out of a total of 24 words). In every case, more correct responses were made in the MR condition relative to the SR condition. Thus, not only were more words mastered during the MR condition, but more total words were read correctly in MR sessions compared to SR sessions.

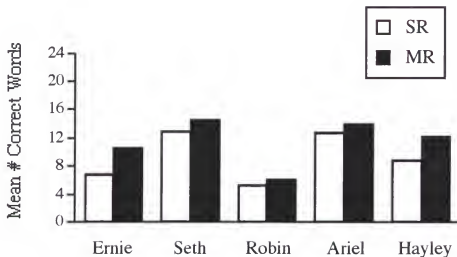


Figure 2. The mean number of correct words read by each participant during single-response (SR) and multiple-response (MR) repetition conditions.

The data in Table 2 provide information about the relative efficiency of the SR and MR procedures. In all cases, MR sessions took more time to complete, although differences between SR and MR session lengths were small (SR mean, 5.1 min; MR mean, 6.4 min). In addition, a slightly larger percentage of intervals was devoted to correcting errors during MR sessions than during SR sessions in 3 out of 5 cases. That is, more intervals within a session were consumed by error correction when 5 repetitions of the word were required, as opposed to when 1 repetition was required.

Table 2. The mean session length and the mean percentage of intervals (% INT) of error correction per session during single-response (SR) and multiple-response (MR) repetition conditions.

|        | Session Length (min) |           | % INT Error Correction |           |
|--------|----------------------|-----------|------------------------|-----------|
|        | <u>SR</u>            | <u>MR</u> | <u>SR</u>              | <u>MR</u> |
| Ernie  | 4.5                  | 5.6       | 69%                    | 67%       |
| Seth   | 9.2                  | 10.9      | 27%                    | 30%       |
| Robin  | 4.3                  | 5.6       | 71%                    | 74%       |
| Ariel  | 3.2                  | 4.5       | 51%                    | 54%       |
| Hayley | 4.1                  | 5.3       | 68%                    | 64%       |

Table 3 shows the results of the retention tests. When short-term word retention was assessed, 3 out of 5 participants read more MR words correctly than SR words. When long-term retention tests were administered, all participants read more MR words correctly than SR words.

Table 3. The percentage of words retained by each participant on short-term and long-term tests during single-response (SR) and multiple-response (MR) repetition conditions.

|        | Short-Term<br>Retention Test |           | Long-Term<br>Retention Test |           |
|--------|------------------------------|-----------|-----------------------------|-----------|
|        | <u>SR</u>                    | <u>MR</u> | <u>SR</u>                   | <u>MR</u> |
| Ernie  | 51%                          | 72%       | 30%                         | 63%       |
| Seth   | 78%                          | 87%       | 67%                         | 77%       |
| Robin  | 53%                          | 64%       | 53%                         | 73%       |
| Ariel  | 85%                          | 81%       | 68%                         | 74%       |
| Hayley | 85%                          | 80%       | 58%                         | 62%       |

Overall, these results indicate that both brief (SR) and more extended (MR) error-correction procedures facilitated sight-word acquisition in adults with developmental disabilities. In every case, the addition of a procedure to correct errors resulted in better performance than that observed when no consequences were arranged for errors (baseline). Comparisons of the two error-correction procedures showed that the MR procedure was superior to the SR procedure along a number of dimensions. That is, the MR procedure resulted in (a) more cumulative words mastered, (b) more words read correctly per session, (c) and more words retained both short- and long-term. These data are consistent with results from other research suggesting that longer durations of error correction produce faster acquisition than do shorter durations (Close et al., 1978; Foxx & Jones, 1978).

A minor limitation of the MR procedure is the amount of time required to complete. More training time was consumed by MR error correction relative to SR error

correction, although the time differences were small. The MR procedure (5 word repetitions) necessarily took longer to administer following incorrect responses than did the SR procedure (1 word repetition). However, the data in Table 2 show negligible differences between the percentage of intervals spent conducting error correction during the SR and MR conditions. Because a nearly equivalent amount of time was spent correcting errors during SR and MR sessions, the difference in training time may have been due to the increased delivery (and consumption) of reinforcers for correct responses in the MR condition.

Because a positive reinforcement contingency was in effect during both baseline and training phases, increases in sight-word acquisition during training cannot be attributed to the effects of positive reinforcement. One likely explanation is that negative reinforcement was responsible for the improvements in performance observed during the SR and MR conditions. To the extent that error correction is a punishing event, individuals may exhibit increases in correct responses to avoid the error-correction procedure.

It is possible that the enhanced performance observed with the MR procedure relative to the SR procedure also was the result of negative reinforcement. Because the MR procedure involved 5 repetitions of the correct word rather than 1 repetition, participants' correct responses may have increased at a faster rate to avoid more extended exposure to error correction. Alternatively, the superiority of the MR procedure over the SR procedure may have been due to extra practice with correct responses. That is, additional repetitions of the correct word required during the MR condition may have served to increase stimulus control over future correct responses.

## EXPERIMENT 2: SCHEDULE OF ERROR CORRECTION

Research on error-correction techniques has focused almost exclusively on procedural implementation following every occurrence of an incorrect response. However, consistent application of an error-correction procedure may not be possible in typical instructional settings. Teachers often do not have adequate support staff available in a classroom to provide consistent feedback to all students during training situations. Therefore, it may be important to consider the effects of intermittent delivery of error correction on acquisition.

In the second experiment of a two-part study, Kircher, Pear, and Martin (1971) compared the continuous and intermittent delivery of consequences for errors during a picture-naming task. Following each incorrect response emitted during training, the therapist said "no" and drew a large "X" on a board. After a fixed number of "Xs" had been accumulated (1, 2 or 4), the therapist delivered a 9 to 15 mA shock to the participant's calf for approximately 25 msec. Fixed-ratio (FR) shock schedules were compared to a no-shock condition, during which just the verbal reprimand ("No") was delivered for incorrect responses. Results showed that FR1 shock delivery resulted in more correct responses by both participants than did the no-shock condition. When 50% of incorrect responses resulted in shock (FR2 shock schedule), one participant displayed more correct responses relative to the no-shock condition, whereas the other participant showed no difference in the percentage of correct responses. Finally, no difference in correct responses was observed between shock and no shock conditions for the one

participant who was exposed to FR4 shock delivery. These findings suggest that better acquisition may be observed when error correction is presented consistently (i.e., after every error) rather than on an intermittent basis.

Varying the consistency with which consequences are arranged for errors may be conceptualized as a manipulation of amount of error correction. Experiment 1 evaluated the parameter of amount by manipulating the number of word repetitions required per incorrect response (1 repetition in SR versus 5 repetitions in MR). In Experiment 2, amount of error correction was further evaluated by comparing consistent (FR1) and intermittent [variable-ratio 3 (VR3)] use of response repetition for errors. Seth, Tess, Ernie, and Becky participated in Experiment 2.

### Procedures

This experiment employed a multiple baseline across subjects design to control for length of time in baseline. Following baseline, two error-correction procedures were compared using a multielement design. During both error-correction conditions, a multiple-response (MR) repetition procedure was used in which five repetitions of the correct word were required, and the conditions differed only with respect to the proportion of errors corrected per session.

#### Baseline (No Error Correction)

A set of eight words was presented in random sequence three times each, resulting in the presentation of 24 words per session. The therapist presented one word card at a time and prompted the participant to read the word. When a correct response occurred, either an edible (Seth) or a ticket (Tess, Ernie, Becky) was delivered. When an incorrect response occurred, it was ignored (i.e., the next word card was presented). At the end of

each session, five small pieces of food (Seth) or five tickets (Tess, Ernie, Becky) were delivered noncontingently to participants for "trying hard."

#### MR (Continuous)

The presentation of word cards, consequences for correct responses, and post-session delivery of reinforcers were identical to the baseline condition. Contingent on each occurrence of an incorrect response, the MR error-correction procedure was implemented. The therapist said, "No, the word is \_\_\_\_\_. Say \_\_\_\_\_." After the correct word was repeated five times by the participant, the next word card was presented.

#### MR (Intermittent)

The procedures used in this condition were similar to those of the continuous MR condition, except that error correction was not provided following every incorrect response. Instead, an average of every third error made was corrected with the MR procedure (i.e., a VR3 schedule of error correction). When an error was scheduled to be corrected, the therapist said, "No, the word is \_\_\_\_\_. Say \_\_\_\_\_," and then prompted the participant to repeat the word five times. Errors that were not corrected were ignored (i.e., the next word card was presented).

### Results and Discussion

The cumulative number of words mastered during baseline and error-correction conditions are displayed in Figure 3. During baseline, the number of words meeting the mastery criterion was small for Seth, Ernie, and Becky (range, 0 to 3). Tess mastered between 1 and 4 words per session during baseline; by the end of the phase, however, her rate of word mastery was leveling off. The introduction of continuous and intermittent MR error correction resulted in increases in all participants' word mastery. The best performance was observed during the continuous MR condition in all cases. Seth showed

the largest difference in acquisition between the 2 conditions, mastering 35 words in the continuous MR condition and 16 words in the intermittent MR condition. These data represent an improvement of 119% in word mastery with the use of continuous as opposed to intermittent error correction. Improvement in word mastery during the continuous MR condition was also evident for Tess, Ernie, and Becky, who mastered 38%, 80%, and 87% more words, respectively, during continuous MR sessions relative to intermittent MR sessions.

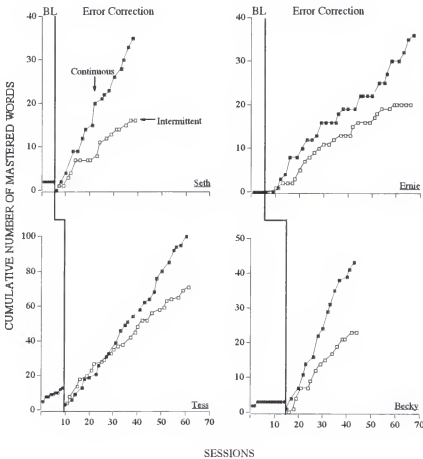


Figure 3. The cumulative number of words meeting the mastery criterion for each participant during baseline (BL), continuous MR, and intermittent MR conditions.

Figure 4 shows the average number of correct responses emitted by each participant per session during continuous and intermittent MR error correction. All 4 participants read more words correctly when every error was followed by the MR procedure (continuous MR) rather than when a varying proportion of errors was corrected (intermittent MR).

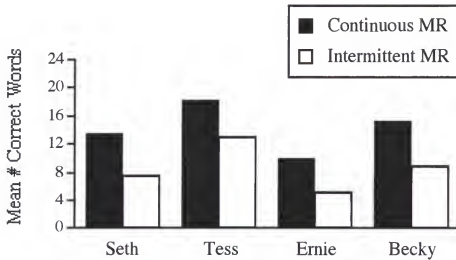


Figure 4. The mean number of correct words read by each participant during continuous MR and intermittent MR conditions.

Table 4 shows the mean session length of each procedure, as well as the percentage of session time consumed by error correction. Whereas Seth's, Ernie's, and Becky's continuous MR sessions took longer to complete than their intermittent MR sessions, Tess' session lengths were equivalent across the two condition. In all 4 cases, however, a larger percentage of session time was devoted to correcting errors in the continuous MR condition relative to the intermittent MR condition.

Table 4. The mean session length and the mean percentage of intervals (% INT) of error correction per session during continuous MR and intermittent MR conditions.

|       | Session Length (min) |                     | % INT Error Correction |                     |
|-------|----------------------|---------------------|------------------------|---------------------|
|       | <u>Continuous</u>    | <u>Intermittent</u> | <u>Continuous</u>      | <u>Intermittent</u> |
| Seth  | 11.0                 | 8.3                 | 38%                    | 26%                 |
| Tess  | 4.9                  | 4.8                 | 34%                    | 17%                 |
| Ernie | 5.3                  | 4.2                 | 36%                    | 20%                 |
| Becky | 4.5                  | 4.0                 | 55%                    | 38%                 |

Table 5. The percentage of words retained by each participant on short-term and long-term tests during continuous MR and intermittent MR conditions.

|       | Short-Term Retention Test |                     | Long-Term Retention Test |                     |
|-------|---------------------------|---------------------|--------------------------|---------------------|
|       | <u>Continuous</u>         | <u>Intermittent</u> | <u>Continuous</u>        | <u>Intermittent</u> |
| Seth  | 85%                       | 69%                 | 82%                      | 82%                 |
| Tess  | 94%                       | 94%                 | 86%                      | 84%                 |
| Ernie | 69%                       | 58%                 | 49%                      | 58%                 |
| Becky | 86%                       | 91%                 | 91%                      | 91%                 |

The results of the retention tests are shown in Table 5. During short-term tests, Seth and Ernie retained more continuous MR words than intermittent MR words, whereas Becky retained a slightly larger percentage of intermittent MR words during short-term tests. Tess retained an equal percentage of continuous MR and intermittent MR words during short-term tests. During long-term tests, Seth and Becky showed no difference in percentage retention across the two error-correction conditions. Tess retained a slightly larger percentage of continuous MR words during long-term tests, whereas Ernie retained more intermittent MR words during long-term tests.

To summarize, all participants demonstrated more word mastery in the condition in which every error was corrected with response repetition (continuous MR). These data are consistent with the findings from Experiment 1, which showed better sight-word performance when error correction amount was increased from 1 repetition to 5 repetitions. Although amount is a parameter that clearly influences sight-word acquisition, the question remains as to why continuous exposure to error correction produces superior performance. It is possible that words are acquired more quickly during the continuous MR condition because consistent error correction better enhances stimulus control over correct responses. By contrast, if the continuous MR procedure is more punishing than the intermittent MR procedure, an avoidance contingency may be set up wherein correct responses increase at a faster rate to avoid the continuous presentation of error correction.

### EXPERIMENT 3: FUNCTION OF ERROR CORRECTION

Most error-correction procedures in which a participant response is required involve what might be called "relevant" practice; that is, correction involves the emission of behavior that is topographically similar to the performance being learned (Foxy & Jones, 1978; Jenkins & Larson, 1979; Ollendick, Matson, Esveltd-Dawson, & Shapiro, 1980). A widely held assumption is that the form of practice during error correction is important, and that topographical similarity between the task and the correction procedure serves an educational function by enhancing stimulus control over correct responses. However, it is possible that practice with "irrelevant" (i.e., non-training) stimuli would produce similar increases in performance, suggesting that negative reinforcement (rather than stimulus control) was responsible for behavior change. Studies have shown that practice with irrelevant (i.e., non-training) stimuli can produce acquisition performance similar to that observed when relevant stimuli are used (Axelrod et al., 1984; Rodgers & Iwata, 1991).

The purpose of Experiment 3 was to compare the rate of sight-word acquisition when topographically similar and dissimilar stimuli were used during error correction. If topographical similarity is unimportant (i.e., if relevant and irrelevant correction are equally effective), then improvements in performance could be attributed solely to negative reinforcement. However, if acquisition is enhanced when error correction is relevant to the training task, then increases in correct responses could be attributed to

enhanced stimulus control. Tess, Ariel, Ernie, Becky, and Hayley participated in Experiment 3.

### Procedures

Baseline lengths were staggered to conform to a multiple baseline across subjects design. Following baseline, relevant and irrelevant error-correction conditions were alternated in a multielement design. Multiple-response (MR) repetition error correction was used across both training conditions, and the procedures differed only with respect to the word that was repeated after an incorrect response was made.

#### Baseline (No Error Correction)

A set of eight words was presented in random sequence three times per session, yielding a total of 24 trials. Word cards were presented one at a time, and participants were prompted to read each word. Correct responses resulted in the delivery of a ticket that was exchangeable for post-session access to preferred items or activities. Incorrect responses were ignored (i.e., they resulted in presentation of the next word card). Following each session, participants received five tickets for "trying hard."

#### MR (Relevant)

The presentation of word cards, consequences for correct responses, and post-session delivery of tickets were identical to the baseline condition. However, contingent on each incorrect response, the therapist implemented MR error correction using the word that was misread. The therapist said, "No, the word is (relevant word). Say (relevant word).". Following five repetitions of the relevant word, the next word card was presented.

### MR (Irrelevant)

Procedures were identical to the relevant condition described above, except that a non-training word was repeated during MR error correction. One irrelevant (i.e., non-training) word was selected from each participant's list of unknown words. When an incorrect response occurred, the therapist said, "No, the word is (relevant word). Say (irrelevant word).". After the participant repeated the irrelevant word five times, the next word card was presented.

### Results and Discussion

The cumulative number of words mastered by each participant during baseline and error-correction conditions is shown in Figure 5. All participants' sight-word performance increased during error correction relative to baseline. Three out of 5 participants (Tess, Ariel, and Ernie) mastered more words during the relevant MR condition, when they were required to repeat the correct word five times contingent on each error. The level of improvement observed from the relevant MR to the irrelevant MR condition was 21% for Tess, 93% for Ariel, and 48% for Ernie. By contrast, the remaining 2 participants' rate of word mastery during relevant MR and irrelevant MR conditions was indistinguishable. Becky and Hayley mastered 50 and 56 words, respectively, during the relevant MR condition, and 46 and 54 words, respectively, during the irrelevant MR condition.

Figure 6 shows each participant's mean number of correct words during each error-correction condition. More words were read correctly during relevant error-correction sessions in 4 out of 5 cases. The most pronounced difference was seen with Ariel, who made an average of 14.2 correct responses during relevant MR sessions, as opposed to 9.2 correct responses during irrelevant MR sessions. Becky was the only

participant who read more words correctly in the irrelevant MR condition, averaging 13 and 14.1 words correct during relevant and irrelevant MR sessions, respectively.

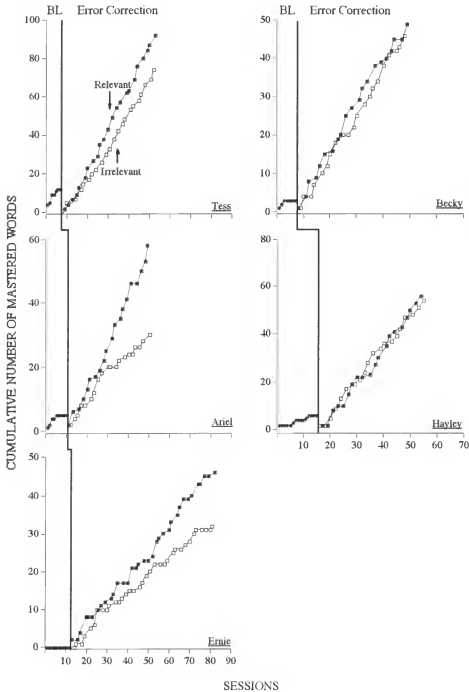


Figure 5. The cumulative number of words meeting the mastery criterion for each participant during baseline (BL), relevant MR, and irrelevant MR conditions.

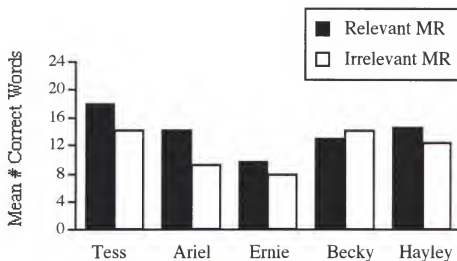


Figure 6. The mean number of correct words read by each participant during relevant MR and irrelevant MR conditions.

The retention test results are displayed in Table 6. The degree of word retention was relatively inconsistent both within and across participants. During short-term tests, Tess' retention was slightly higher when relevant MR words were tested. However, Tess retained an equal percentage of relevant MR and irrelevant MR words on long-term tests. Ariel retained more relevant MR words during short-term tests, whereas she retained more irrelevant MR words during long-term tests. Ernie's short-term and long-term retention was better when irrelevant MR words were tested. Although Becky and Hayley showed no difference in word mastery performance between the two error-correction conditions, both women read a larger percentage of relevant MR words correctly during short- and long-term retention tests.

Table 6. The percentage of words retained by each participant on short-term and long-term tests during relevant MR and irrelevant MR conditions.

|        | Short-Term Retention Test |                   | Long-Term Retention Test |                   |
|--------|---------------------------|-------------------|--------------------------|-------------------|
|        | <u>Relevant</u>           | <u>Irrelevant</u> | <u>Relevant</u>          | <u>Irrelevant</u> |
| Tess   | 94%                       | 89%               | 94%                      | 94%               |
| Ariel  | 91%                       | 82%               | 74%                      | 87%               |
| Ernie  | 72%                       | 75%               | 57%                      | 66%               |
| Becky  | 92%                       | 85%               | 82%                      | 79%               |
| Hayley | 82%                       | 72%               | 75%                      | 57%               |

These results replicate and extend the results obtained in Experiments 1 and 2.

The relevant MR procedure effectively increased the sight-word reading skills of 5 participants relative to baseline. In addition, a variation of the MR procedure, in which irrelevant (i.e., non-training) stimuli were repeated, also produced increases in sight-word performance in all 5 participants.

Mixed findings were obtained with regard to the effectiveness of relevant versus irrelevant error correction. Whereas 3 of the 5 participants performed better when relevant (topographically similar) stimuli were used, 2 of the participants performed equally well during both error-correction conditions. None of the participants performed better during the irrelevant MR condition. Although uniformly better sight-word

performance was not associated with one particular condition in Experiment 3, these data do shed light on the process(es) operating during error correction.

In the first two experiments, Ernie's sight-word acquisition was more rapid under the conditions in which (a) five response repetitions were provided per error (Experiment 1), and (b) every incorrect response resulted in error correction (Experiment 2).

Collectively, these results suggest that (a) Ernie's behavior was sensitive to amount of response repetition, and (b) either practice or avoidance may have been responsible for the performance observed when greater amounts of error correction were used. The results obtained during Experiment 3, however, seem to support a stimulus control (practice) interpretation for Ernie's data. That is, when amount of error correction was equated (i.e., when every error resulted in five word repetitions), better sight-word performance was observed in the condition in which relevant repetitions were required.

A similar explanation may account for Ariel's and Tess' results obtained during Experiment 3. In both cases, better performance was observed when amount of error correction was increased, i.e., Ariel performed better during MR sessions relative to SR sessions (Experiment 1), and Tess performed better during continuous MR sessions relative to intermittent MR sessions (Experiment 2). Results of Experiment 3 showed that the relevant MR condition improved sight-word skills better than did the irrelevant MR condition, suggesting that error correction primarily served a stimulus control function for Ariel and Tess.

By contrast, Hayley's and Becky's results during Experiment 3 are more consistent with a negative reinforcement interpretation. Although both Hayley (Experiment 1) and Becky (Experiment 2) performed better when amount of error

correction was increased, neither participant showed enhanced results in the relevant MR condition during Experiment 3. Sight-word acquisition occurred at an equal rate regardless of whether the stimuli presented during error correction were similar or dissimilar to the training task. Thus, it appeared that error correction improved Hayley's and Becky's performance through negative reinforcement.

## GENERAL DISCUSSION

Results of studies on behavioral acquisition consistently have shown that performance is enhanced when consequences are arranged both for correct and incorrect responses (Brackbill & O'Hara, 1958; Jenkins & Larson, 1979; Matson, Esveldt-Dawson, & Kazdin, 1983; Ollendick et al., 1980; Singh & Singh, 1986, 1988; Stevenson, Weir, & Zigler, 1959; Whitehurst, 1969). However, the contribution of error correction to acquisition performance is often de-emphasized. In the present study, the use of response-repetition error correction resulted in improvements in sight-word reading in all participants, indicating that the procedures used to correct errors play a significant role during behavioral acquisition.

In Experiments 1 and 2, amount of error correction was manipulated in two different ways to determine its influence on sight-word performance. Experiment 1 assessed the extent to which number of repetitions during error correction (1 repetition versus 5 repetitions) affected acquisition. By contrast, Experiment 2 evaluated amount of error correction by varying the consistency with which error correction was applied following incorrect responses. Regardless of the manner in which amount was manipulated, results indicated that "larger" amounts of error correction produced better sight-word performance than "smaller" amounts. These results replicate those of other studies that have shown enhanced effects when error-correction amount is increased (Close et al., 1978; Foxx & Jones, 1978; Kircher et al., 1971).

Although increased amounts of error correction resulted in superior sight-word performance, there may be limitations associated with the extended use of error-correction procedures. First, longer durations of error correction may be associated with the occurrence of negative side effects such as aggression and disruption (Carey & Bucher, 1983). In the present study, no data were collected on the occurrence of negative side effects, so the extent to which the MR procedure is associated with negative side effects is unknown. Therefore, more research is needed to determine the relative probability of negative side effects during short- and long-duration error correction.

Second, given an overabundance of classroom obligations, teachers may be unable (or unwilling) to implement procedures that require lengthy error correction. Results of the current investigation revealed negligible differences in training time between short and long durations of error correction. Nevertheless, it is possible that a great deal of classroom time could be consumed when error correction is of extended (versus brief) duration. In these cases, it may be important to balance effectiveness with practicality. If a lengthy error-correction procedure is shown to produce a much more robust effect, then its use seems justified despite the increase in training time. By contrast, if minimal improvements are observed when error-correction amount is increased, then it may be more practical to select the procedure that consumes less training time.

The present study represents one of only a few studies (Axelrod et al., 1984; Rodgers & Iwata, 1991) in which there was an attempt to identify the learning mechanisms responsible for improved performance during error correction. When skill acquisition occurs, researchers almost universally attribute increases in performance to

positive reinforcement. Although negligible acquisition of sight-word reading was observed in the present study when consequences were arranged only for correct responses (baseline), acquisition has been shown to occur in the absence of an error-correction contingency (Bennett, 1974; Charlop & Walsh, 1986; Rodgers & Iwata, 1991). It is possible that sight-word performance may have increased for some participants had baseline phases been prolonged, but because the focus of this study was on the effects of error correction, baseline lengths were not extended.

Although there is no doubt that positive reinforcement is partially (or in some cases, fully) responsible for establishing novel skills, the potential contribution of other learning processes cannot be ignored. One alternative account of behavioral acquisition is based on negative reinforcement, that is, correct performance may occur to avoid the consequence programmed for errors. Little is known about the independent influence of negative reinforcement on acquisition because most error-correction studies have included a positive-reinforcement contingency for correct responses. Of the few studies that have arranged consequences only for errors, all have shown increases in correct performance, thereby demonstrating the utility of negative reinforcement in producing acquisition (Ollendick et al., 1980; Penney & Lupton, 1961; Whitehurst, 1959). In the current study, rewards were delivered for correct responses during both baseline and error-correction phases; as a result, differences in sight-word performance observed from baseline to treatment could not be attributed to the effects of positive reinforcement. The only change from baseline to treatment was the introduction of error correction for incorrect responses, and this change resulted in increases in sight-word reading skills. Given that error correction always could be avoided during treatment by engaging in

correct responses, negative reinforcement must have contributed to some of the improvements observed in sight-word reading during this study.

Another alternative account of behavioral acquisition is based on enhanced stimulus control. In addition to serving an "aversive" (negative reinforcement) function, error correction also may serve an educational function by providing repeated practice with the correct response. In most studies, error correction involves repeated practice with the training stimulus after an incorrect response occurs, presumably so that the correction procedure may exert some stimulus control over future correct responses. During each of present experiments, practice with the relevant training stimulus (i.e., the correct word) was provided following errors, and this feature also likely contributed to the improvements observed in sight-word reading.

Experiment 3 attempted to separate the effects of avoidance from those of practice by including a condition in which an irrelevant (i.e., nontraining) word was repeated during MR error correction. Findings were mixed in that not all participants showed superior effects in the same error-correction condition. Exposure to relevant training stimuli produced better performance for some participants, and these results are most consistent with a stimulus control interpretation. In the other cases in which performance was equal across error-correction conditions, a negative reinforcement interpretation is more plausible. This variability across participants suggests that individual histories likely affect the way in which other variables (e.g., error correction) influence performance.

Error-correction procedures are often quite intricate and diverse, and relatively few studies have been conducted to compare their relative efficacy. The current study

systematically evaluated one form of error correction (response repetition) for its effects on one behavior (sight-word reading) among one participant population (adults with developmental disabilities). As a result, the generality of these results is unknown. Future research should assess the utility of response-repetition error correction in improving other behaviors (e.g., other academic, vocational, or self-care skills) among other populations (e.g., persons without disabilities, students with learning disabilities). More comparative and parametric analyses also are needed to determine which procedural variations of error correction produce the best acquisition performance.

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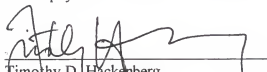
### BIOGRAPHICAL SKETCH

April Susan Worsdell was born in Miami, Florida, in 1974. She received her Bachelor of Science degree in psychology in 1996 from the University of Florida. During her undergraduate studies, she had the opportunity to work as a research assistant at the Florida Center on Self-Injury, during which time she gained experience in the assessment and treatment of severe behavior disorders. This experience led her to seek employment at the Kennedy Krieger Institute, where she obtained additional clinical research training. In 1997, she returned to the University of Florida to pursue graduate studies in behavior analysis. She worked as a graduate assistant at the Florida Center on Self-Injury from 1997 to 2002 under the direction of Dr. Brian Iwata. Expecting graduation in 2002, she has accepted a position as a behavioral psychologist at Bancroft Neurohealth, where she will continue to conduct behavior-analytic research on the assessment and treatment of problem behavior in persons with developmental disabilities.

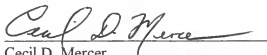
I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

  
Brian A. Iwata, Chairperson  
Professor of Psychology

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Timothy D. Hackenberg  
Professor of Psychology

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Cecil D. Mercer  
Distinguished Professor of Special Education

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Scott A. Miller  
Professor of Psychology

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This dissertation was submitted to the Graduate Faculty of the Department of Psychology in the College of Liberal Arts and Sciences and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

August 2002

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Dean, Graduate School